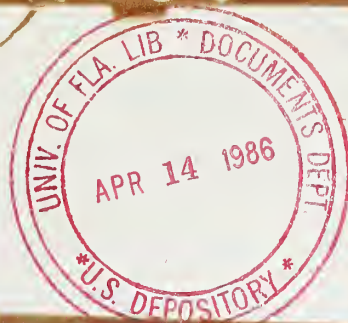


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Combat Crew

Strategic Air Command

APRIL 1986



DETERRENCE

A Planner's Perspective

Maj Gen Jack K. Farris
Deputy Chief of Staff, Strategic Planning and Analysis



In the summer of 1959, I became "combat ready." I very clearly recall certifying to our wing commander, in all the detail our B-47 crew could muster, our ability to carry out our Emergency War Order mission if called upon. From normal procedures to emergency procedures, TAC doctrine, communications, and contingency questions by the staff, every facet of the mission was discussed. As a brand new co-pilot, I was sobered by the responsibilities placed on our crew and the trust and confidence placed in us. I was fortunate to be bolstered by my two highly experienced fellow crew members who helped guide my daily training and mission preparation.

My aircraft commander, for example, had over 10,000 hours of Air Force flying time including missions in World War II and the Berlin Airlift. In fact, he had 2500 hours of B-47 instructor pilot (IP) time alone. Our radar navigator was a B-24 bombardier in World War II, and had been shot down over Germany and captured. These distinguished aviators were the best teachers one could have. They understood and gave special meaning to the term "combat crew"; for they had experienced the stress of a combat environment. Most of the younger crew members could only imagine the rigors of armed conflict.

Today, this country continues to place great confidence and reliance in you, the combat crews; however, we are again finding our young force more and more distantly removed from the combat experience. The average B-52 crewmember of today, for example, was 12 years old during the famous Tet offensive and nearly 17 by the time LINEBACKER II was flown. Clearly this gap in exposure to hostile action is exactly what best serves national objectives. SAC's combat ready forces should continue to take great satisfaction in the fact that readiness and deterrence have been convincing

enough that our military forces have not again been called into action. This deterrence continues to be made up of many factors, including upgraded equipment, new weapon systems, advancing technologies, and realistic training. The key ingredient which binds this combination together, however, continues to be you, the combat crew member.

While America now enjoys peace, we continue to see throughout the world many examples of the clairvoyance of the philosopher, Plato, who said, "Only the dead have seen the end of war."

Should the forces of this command ever be called upon to enter a conflict of any magnitude, the ultimate outcome rests not with the senior leadership, not with the SAC staff, not with our policy makers; but with the readiness, resourcefulness, reliability and capability of you — the combat crew force. As you strive to maintain the competitive edge, you must take advantage of every training opportunity, every exercise, and every technology upgrade to test and sharpen your skills. In doing so, you have every right to be proud of your heritage and your title — you earn that right every day.

In 1959, I had no way to forecast the perspectives from which I would view SAC's role in the TRIAD or the capabilities of the combat crew force throughout my career. In my present capacity, I have the fullest appreciation of your responsibilities and the dedication with which you do your job. You must continue to be as good as you can be, thereby providing the shield and guardian of our nation's freedom. Isn't it ironical then, that only if deterrence fails will you ever become a veteran of combat? This must always be our collective goal — yours, mine, SAC's, and the Air Force's — to be so good at what we do, and so convincingly ready for any eventuality, that our combat forces will never need to be used in anger. We wouldn't want it any other way!

★ ★

Combat Crew

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On Our Cover

Various terrain avoidance myths have been developed through the years. Have you ever been under their influence? Turn to page 12 and find out.

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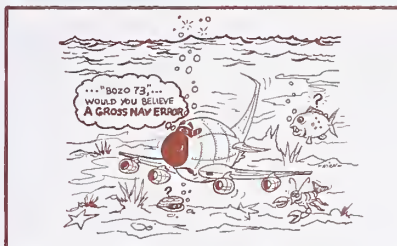
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OLYMPIC ARENA — SAC'S 1986
Missile Combat Competition

Just Another Ocean Crossing, Almost...

As I scanned the sky in one last futile attempt to locate Halley's Comet, my mind drifted back to more earthly pursuits — the next week in Europe. In spite of the o'dark thirty departure, the hassle of finally locating a current North Atlantic Organized Track (NAT/OTS) message at the comm center and the typically hectic mission planning and on-time departure, the flight settled down to another routine oceanic crossing with its accompanying sensations of suspended animation and solitude.

As I relaxed and absorbed the tranquility, I began to eagerly anticipate our arrival in Europe and started to mentally plan crew rest activities: fish, chips and bitters at Mildenhall's Bird-in-Hand; shopping in London; sauer-

braten and zeller schwartz katz in Rhein Main; veal scallopini and vino in . . . My solitude was sharply broken by a typically crisp British voice on 126.7.

"Bozo 73, this is Shannon." My mind snapped back into the real world as I responded, "Go ahead, Shannon, this is Bozo 73."

"Bozo 73, Shannon, squawk 5327, ident."

"5327 ident, Bozo 73." Even in this day of modern miracles such as INS, it's still reassuring to hear a friendly voice on VHF indicating you've successfully completed another crossing I thought as I tuned in the Shannon VOR.

"Bozo 73, this is Shannon, you are radar identified 60NM north of track;



Lt Col Gerald M. Davis
HQ USAF/XOORF

are you having any difficulties?"

Sixty nautical miles north of track! Am I having any difficulties? My mind raced as I frantically checked the INS. What's happening? What's the problem? Both "ready nav" green lights are on; both HSIs centered; autopilot engaged; no warning lights; both INS present positions indicate 53N, 15W; flight plan coordinates 53N, 15W; everything looks okay as it has for the entire crossing. Nothing appears wrong; Shannon must be mistaken. We couldn't be off . . .

"Bozo 73, Shannon."

"Shannon, Bozo 73, we show our position as 53N, 15W on both INS' which agrees with our flight plan."

"Bozo 73, Shannon, your position is confirmed, however, we show your route of flight as 54N/30W, 53N/20W, 52N/15W, Shannon, instead of 53N/15W. Sir, please be advised that we'll have to file a gross navigation error report. You are in conflict with Air France flight number 326 estimating 53N/15W at 0637 Zulu."

"Roger, Bozo 73."

"Bozo 73, Shannon, you are re-cleared 53N, 15W direct Shannon, flight plan route."

"Roger, direct Shannon, flight plan route, Bozo 73."

Gross navigation error! 60NM north! I'm really in trouble, I thought, envisioning OPREP 3 messages, commanders, explanations, downgrades, investigations, retraining, requalification — No Good Times in Europe!

I still couldn't believe this could be true as that uneasy, sinking feeling rushed up behind me. Now I was wide awake! As the adrenalin cleared the cobwebs, I frantically searched for the explanation, reconstructed the past few hours and went through my mental oceanic checklist. Oceanic clearance; received on VHF from Gander — "Track Uniform, FL350, Mach .78 for the crossing." Oceanic waypoints cross-checked; the copilot had read out the coordinates and I had cross-checked the INS programming. INS waypoint cross-checks; since this was my leg, I had cross-checked the INS' at each waypoint — both systems normal. Radio INS switches; both switches were in INS and coupled to the autopilot. Track message; flight plan and INS programming cross-checked against

the track message — all okay. Whoa, wait a minute! When the copilot read back the coordinates during the oceanic waypoint cross-checks, was he reading from the track message or from the flight plan? Bill's a sharp guy; it had to be the track message, right?

"Hey, Bill, wake up!"

"What?"

"Wake up!"

"What's going on, Charlie?"

"As I relaxed and absorbed the tranquility, I began to eagerly anticipate our arrival in Europe and started to mentally plan crew rest activities."

"Bill, when you read back the coordinates for the oceanic waypoint checks, did you use the track message or the flight plan?"

"The computer flight plan, I think, what's wrong?"

That sinking feeling got worse as I said, "Shannon just told us that we're 60NM north of course and they're filing a gross nav error, let me see that track message." I again had visions of commanders, downgrades, hassles . . .

I grabbed the track message from Bill and quickly compared its coordinates with the flight plan. They were the same, weren't they? One more check to be sure. Oh no! A second, slower scan found one subtle but important difference. The computer flight plan was 53N/20W, 53N/15W, SNN; but the track message was 53N/20W, 52N/15W, SNN. Finally, the brutal reality of the situation came sharply into focus. The controller was right! We were wrong! Our friendly flight planner had set a subtle trap for us and in our rush during mission planning we fell into that trap. Although we had checked the flight plan against the track message we had missed this one critical difference. The controller was more correct than he knew; we were having difficulties and these difficulties would certainly increase as soon as we landed. Goodbye good times!

Is This Story Real?

Although this particular story is fictitious, the USAF gross navigation er-

ror problem is very real, and this story is typical of the majority of USAF North Atlantic gross navigation errors. Recent gross navigation errors involving USAF aircraft in the North Atlantic (NAT) indicate a potentially serious degradation in navigation performance which could adversely impact the operational flexibility and efficiency necessary to effectively accomplish our mission.

It is somewhat surprising and informative to note that most gross navigation errors have at least two common factors: the navigation equipment functioned normally and the aircraft was navigated with precise knowledge of position to the wrong place. These errors are usually caused by an inadequate understanding of North Atlantic Minimum Navigation Performance Specifications (MNPS) airspace operation and procedures and/or mismanagement of the navigation and flight guidance systems.

How Gross is a Gross Navigation Error?

A "gross navigation error" is internationally defined as an unauthorized deviation of 25NM or more from the exact centerline of the route of flight assigned by ATC. The process of obtaining an ATC clearance is actually a negotiation process between the aircrew and the ATC controller. When the controller issues a clearance, ATC is automatically agreeing to provide you with the required separation (air traffic services) from all known IFR traffic. The primary air traffic service is the prevention of collision. When you accept an ATC clearance, you are agreeing to operate the aircraft so as to always remain within the area assigned by ATC. This principle is of paramount importance in oceanic areas since ATC does not have independent knowledge of your actual position and must depend entirely on position reports to identify potential conflicts. In NAT/MNPS airspace, the ATC lateral separation minima is 60NM which means that acceptance of an ATC clearance means that you have agreed to always remain within ± 30 NM of the exact centerline of your assigned route of flight. Any navigation error of 30NM or more means that you have deviated from your "protected" air-

space, blundered into another aircraft's "protected" airspace, and become a collision hazard to yourself and others.

What is This NAT/MNPS Stuff Anyway?

The MNPS concept was adopted by the International Civil Aviation Organization (ICAO) following its endorsement in 1976 by ICAO's 9th Air Navigation Council. In adopting this concept, ICAO stipulated two basic guidelines for the establishment of an MNPS: a safety need must be clearly identified; and economic benefits must be provided to the majority of the users of this airspace. Acceptance of the MNPS concept represented a major philosophical change in ICAO's approach to standards and recommended practices for navigation systems and ATC separation minima. The MNPS concept specifies the required overall navigation performance, including the aircrew's ability to use the systems, instead of specifying accuracy requirements for the equipment and/or requiring specific navigation systems.

Where is NAT MNPS Airspace?

The NAT/MNPS airspace is defined as that oceanic airspace in the North Atlantic between FL275 and FL400; between the latitudes of 27 degrees North and the North Pole. The boundaries of NAT/MNPS airspace are depicted on North Atlantic IFR Enroute Charts (U.S. H 3 and H 4, and Canadian HE1, HE4, LE10). The best depiction of the NAT/MNPS is on the Canadian LE10 IFR Enroute Chart.

Incomprehensible Mathematician's "Flute Music" Made Semi-understandable

Mathematical "Collision Risk Methodology" (CRM) is inherent to the MNPS concept. The CRM is based on an internationally agreed "Target Level of Safety" (TLS) which represents the probability of a mid-air collision due to inadequate navigation performance. To understand collision risk methodology, it is necessary to understand navigation performance. In the MNPS concept, navigation performance can be thought of as any deviation for any reason from the exact centerline of the route of flight specified in the currently effective ATC clearance. Navigation performance includes errors due to position errors in-

herent to the navigation system being used (accuracy); errors due to navigation equipment malfunction/failure (reliability); errors due to misunderstandings between the crew and ATC concerning the route to be flown; and errors due to misunderstandings between ATC units concerning the assigned route of flight. In other words, navigation performance is the overall

"I still couldn't believe this could be true as that uneasy, sinking feeling rushed up behind me. Now I was wide awake!"

performance of the ATC system. Since controlling the risk of collision to an acceptable level is fundamental to MNPS and flight safety, any error which could result in a mid-air collision must be analyzed and controlled.

Since safety of flight in the NAT is dependent on continuously maintaining the required level of navigation performance, radar observation "windows" have been established in eastern Canada, western United Kingdom, Ireland, and western France to detect aircraft which have inadequate course keeping ability. During the last reporting period (1 Mar 84 to 28 Feb 85) approximately 102,000 aircraft were radar observed exiting oceanic airspace at these windows. Approximately 12,000 of these aircraft were military. Any aircraft observed by radar to be 30NM or more from the exact centerline of the assigned route is reported to the State of Registry as a gross navigation error. This report includes a request for investigation to determine the cause of the error. For 10,000 observations (approximate number of USAF operations), the MNPS criteria allow five errors of 30NM or more and only one error which is within 10NM of a multiple of the separation standard (50 - 70NM, 110-130, etc.). During the last reporting period, the USAF had six errors. Since 1 Mar 85, the USAF committed 13 errors of 30NM or more and 7 separation standard errors which has concerned the international community, the DOD, and ICAO states monitoring flight safety in the North Atlantic.

What the Mathematicians "Flute Music" Means to You

Your navigation performance in NAT/MNPS airspace is an open book for the international community to read. Your flight will be radar monitored as you exit oceanic airspace and your position-keeping error will be recorded. If you are as unfortunate as Charlie and Bill and exit oceanic airspace at a radar observation window 30NM or more from the exact centerline of your assigned route of flight, a formal gross navigation error report will be forwarded to your unit for investigation. These reports attract a lot of attention in high places and are a sure way to "blow" your low profile.

The NAT/MNPS criteria are extraordinarily demanding when you personalize them. They mean that each individual crew member cannot make more than one mistake in 1887 oceanic crossings (15,000 flying hours) which would result in an error of 30NM or more; or one mistake in 7693 oceanic crossings (61,000 flying hours) which would result in a separation standard error (50-70NM, 110-130NM, etc.). From this, it should be painfully obvious that we are not permitted even one mistake of these magnitudes in our entire flying career!

Root Causes of USAF Gross Navigation Errors

During the early days of NAT/MNPS, the USAF fleet transitioned



from manual navigation (using Doppler, LORAN, pressure pattern, celestial and dead reckoning) to automatic electronic long range navigation systems such as INS and OMEGA. This transition significantly improved the accuracy and reliability of the navigation function. However, as a direct result of this transition, the character of the USAF gross navigation errors changed from random errors due to position uncertainty to navigation very precisely to the wrong place due to misunderstandings and/or mismanagement of the automated systems. Although the number of USAF formal navigation errors was reduced following this transition, the current error rate exceeds the MNPS maximum allowable rates.

The fact that the gross error rate currently exceeds the maximum allowed by MNPS after USAF aircraft were equipped with navigation equipment capable of meeting the MNPS suggests latent unresolved operational problems. A review of these errors reveals two common and somewhat surprising factors: the navigation equipment functioned normally (no equipment failures); the aircraft was navigated with precise knowledge of position to the wrong places. Although the rate of occurrence is much less frequent, these two factors are also common to civil aviation gross errors. Some of the significant factors which contribute to USAF gross errors are:

- Inadequate understanding of the ATC clearance, e.g., flew flight plan route.

- Operational procedures not compatible with MNPS operation, e.g., autopilot not coupled to the INS/OMEGA, flying headings provided by the navigator.

- Inadequate mission planning, e.g., failure to adequately cross-check flight plan against track message.

“Our friendly flight planner had set a subtle trap for us and in our rush during mission planning we fell into that trap.”

- Inadequate crew coordination, e.g., ATC clearance not common knowledge in the cockpit.

- Inadequate operating procedures for cross-checking navigation equipment, e.g., incorrect waypoint programmed.

- Inadequate cockpit documentation, e.g., track message not available to the crew, computer flight plan not compatible with NAT/OTS structure.

- Inadequate understanding of MNPS operational requirements, e.g., not obtaining oceanic clearance prior to entry.

Further analysis of USAF errors shows two relatively distinct groups. In one group the navigation equipment is operating properly with an incorrect waypoint or route of flight programmed by the flight crew. In the other group, the navigation equipment is properly programmed but is not used as the primary steering reference; the aircraft is flying headings while the navigator practices manual navigation.

Experience has shown rather conclusively that navigation by manual means cannot meet MNPS requirements. This fact was the primary reason for the creation of MNPS and the necessity of automated equipment to meet these requirements. Additionally, it is generally agreed within international groups that manually steering the INS/OMEGA is inadequate to meet the MNPS, especially if the cross track information is not presented to the pilots on the HSI/CDI thereby creating the need for pilots to fly headings provided by the navigator. It is also

generally agreed internationally that Doppler systems require constant attention to inflight rating and compensation for systematic errors and that future installation of Doppler cannot be recommended for unrestricted MNPS operation. USAF operations with Doppler generally do not diligently apply the sophisticated compensation techniques necessary to achieve the precision required by MNPS (mean error no greater than 6.3NM). The bottom line is the fact that, although a single INS or single OMEGA combined with a navigator may have the accuracy necessary to meet MNPS, the operational procedures applied to their use do not meet the overall performance requirements of MNPS.

The civil operators have already learned the hard way (through bad experiences) that airborne navigation equipment, training programs, operational procedures, preflight activities, guidance and regulatory material and their operational control system must be specifically tailored for MNPS operation to reduce the occurrence of errors to an acceptable level. A major element in resolving these types of errors involves enhancing understanding and appreciation of the unique aspects of NAT/MNPS operation by aircrews and support personnel alike.

It'll Never Happen to Me

We all have a tendency to think it can't happen to us. "We're more professional than the dummies who get caught." The only thing I can say is that experience shows there are those who have and those who will. History in the North Atlantic clearly shows that even the most highly experienced crews are involved in gross navigation errors and there is some evidence that highly experienced civil crews make these mistakes more frequently than civil crews new to the NAT. It could be that familiarity breeds complacency since many of the errors have subtle causes where a moment's inattention sets the trap.

What is the Bottom Line?

The most significant thing to remember is that safety of flight in the North Atlantic is totally dependent on your performance and professionalism. The system is only as safe as you are and you can make it unsafe for everyone else!



R&M

Time To Play Hardball!

Capt Dave Graham
HQ SAC/XPRM

“What? Another mission abort? When will someone get a reliable system for this aircraft?” This is one crew member who already understands the need for reliable and maintainable equipment. Until now, emphasis on new systems acquisitions and fielded systems modifications has been focused primarily on cost efficiency considerations. Enter reliability and maintainability (R&M). The Air Force has recently renewed its commitment to R&M in an effort to improve its overall warfighting capability. This commitment will have far-reaching impacts on operators, maintainers, planners, transporters, and suppliers. Operational necessities and logistics issues demand we start playing “hard ball” with R&M. Our future warfighting capability depends on it!

One might ask “What can R&M do for me?” The answer probably depends on one’s perspective. First, we are all Americans dedicated to one ultimate goal — to defend the security of the free world. It is a known fact R&M are critical elements of our effective warfighting capability. Improved R&M, coupled with technological advances and a dedicated and highly trained workforce, will ensure airpower will be ready and available wherever and whenever it is needed. Second, regardless of whether you are an operator, maintainer, programmer, supplier, or transporter, improved R&M will make your job easier, safer, and/or more effective. Finally, we all live in an environment where defense dollars are becoming more and more scarce. The AF must act responsibly and with keen foresight when spending taxpayers’ dollars. We cannot and should not expect the public or Congress to support our stated requirements unless we unequivocally demonstrate prudent judgement concerning the spending of SAC dollars.

Aside from strong and effective fiscal management, greater R&M in our combat and combat support sys-

tems can exert a tremendous effect on reducing operations and support cost. There have been many documented “success” stories published in a variety of magazines, articles, and journals which attest to this fact. Reliable weapon systems reduce life cycle cost, require fewer spares, reduce man-hours, and result in greater mission readiness and sortie effectiveness.

Equally important, good reliability and maintainability improve the mobility, sustainability, flexibility, and survivability of our forces while significantly reducing dependence on airlift and prepositioning of critical logistics assets.

To achieve the full potential R&M offers, a fundamental change is needed in the way SAC approaches, considers, and manages R&M. That does not mean SAC has been soft on R&M over the years, it just means current and future battlefield environments demand we do more. R&M improvements are not simply

limited to future systems, however. Many of our current systems will be with us well into the next century. It is essential we increase their combat effectiveness and supportability now! This can only be achieved through significant improvements in R&M via modification and component/product improvement programs. To illustrate this point, look at the KC-135 Modernization Program. Due to the improved R&M of the KC-135R engine, jet engine intermediate maintenance will be performed at three Centralized Intermediate Repair Facilities (CIRF) instead of having “blue suit” repair capability at each operating base. This organizational change, in turn, generates significant manpower savings. In fact, SAC identified and “turned in” 50 manpower authorizations for FY 87-88 and 90 slots for FY 89-91. An estimated 100 additional manpower spaces could be saved by FY 92 and beyond, depending on the final KC-135R force structure. Another impressive R&M success story pertains to the B-52G/H Offensive



“Operational necessities and logistics issues demand we start playing “hard ball” with R&M. Our future warfighting capability depends on it!”

Avionics System (OAS) modification. The ASQ 38 Bombing Navigation System was experiencing a mean time between failure (MTBF) of 3.5 hours. Additionally, experts from Warner Robins Air Logistics Center projected this system would be unsupportable by FY 86. Although numerous constraints did not permit resolution of all supportability problems during the OAS modification, the new OAS is now demonstrating a MTBF of 18 hours and the strategic radar MTBF is projected to increase from the current 7-8 hours to an impressive 57 hours — a 700 percent improvement. Advances such as these will take us far in attaining the operational goals outlined in the Air Force's Action Plan, **R&M 2000**.

In a 17 September 1984 Action Memorandum, the Secretary and Chief of Staff of the Air Force renewed the AF's commitment to reliability and maintainability (R&M) for both current and future weapon systems. An AF R&M working group was formed to review the current state of R&M. As part of the working group, an Action Plan Development Team authored, and the SECAF and CSAF approved, an action plan called **R&M 2000**. This plan was prepared to institutionalize the renewed commitment to improved R&M across all weapon systems. As evidence of this renewed commitment, the Air Staff established a new office for R&M. A Special Assistant (General Officer) for R&M (AF/LE-RD) now serves as the focal point for R&M throughout the AF. Additionally, this office will integrate the efforts of Research and Development and Logistics communities and oversee the execution of **R&M 2000**.

The benefits of improved R&M are substantial. **R&M 2000** has categorized these benefits into the following five broad areas called operational support goals:

- Increase effective warfighting capability.
- Increase survivability of our combat support structure.
- Decrease mobility requirements per deploying unit.
- Decrease manpower requirements per unit of output.
- Decrease cost.

Mission success is ultimately contingent upon achieving these goals. Greater combat effectiveness, mobility, and flexibility can be realized through greater commitment to R&M through motivated people working in a supportive environment. This approach is outlined in the newly published “SAC R&M Action Plan” dated 1 October 85. The SAC Plan documents SAC's total commitment to accelerated improvements in R&M and specifically outlines the command's multifaceted approach toward achieving greater combat capability with less

dependency on our combat support structure.

To accelerate improvements in R&M, SAC also established a new office for Reliability and Maintainability. The HQ SAC Directorate of Requirements, R&M Division (XPRM), is managed as a joint division under the HQ SAC Deputy Chief of Staff for Plans (HQ SAC/XP) and the Deputy Chief of Staff for Logistics (HQ SAC/LG). The HQ SAC/XP maintains administrative responsibility for the new division, but the decision-making process encompasses a coordinated effort between the XP and LG communities. This division will help focus, coordinate, and advocate SAC's diverse R&M improvement efforts. Additionally, XPRM will provide a more supportive environment for command personnel to define R&M requirements in new systems and “find and fix” problems in fielded systems. To set the SAC program in motion, eight manpower positions, spanning many operational and logistics disciplines, were taken from other HQ SAC offices to create XPRM.

A key feature of SAC's approach includes the need to clearly specify R&M in all requirements documents and obtain the necessary support from DOD contractors. Additionally, R&M will be considered on a co-equal basis with cost, schedule, and performance during the decision-making process. Another key feature includes developing a methodology to track weapon system performance and assess this performance in terms of established operational support goals. Only then can we accurately prioritize the allocation and distribution of critical resources to provide the most “bang for the buck.” But most importantly, SAC needs the support of all people spanning all functional areas before significant improvements can be fully realized. Therefore, each SAC field unit and selected HQ SAC offices have appointed an R&M focal point. SAC R&M focal points will provide the interface necessary to assist in identifying R&M problems occurring in the field and become a forum for generating proposed courses of action. This “find and fix” approach will help ensure SAC achieves the goals and objectives outlined in **R&M 2000**. Higher weapon system R&M will benefit everyone in the operational and logistical arenas. This philosophy and renewed commitment will span not only aircraft systems, but also missiles, orbiting vehicles, and ground systems. Our challenge is to clearly define “hard” R&M requirements for new systems and “find and fix” R&M problems in fielded systems. By working together to clearly define R&M requirements and refusing to accept unreliable, unsafe, and hard to maintain systems, SAC will maintain a warfighting capability second to none. *Let's get tough with R&M!* 

Questions

SIFC, Castle AFB

This month we are going to discuss several subjects we've received questions about recently. After some research, we found that the answers to these questions weren't quite as straightforward as we first thought. Let's jump right in and get to the first one.

Q: My aircraft is category "D," which I know is based on a maximum airspeed of 166 knots on final. Does this also mean that my maximum airspeed during a published missed approach should be 166 knots if no category "E" minimums are published?

A: No, in designing a missed approach procedure, the TERPs specialist uses a higher airspeed than 166 KIAS to provide obstacle protection for category "D" aircraft. To understand this completely, let's compare the airspace criteria for circling procedures with the airspace criteria for missed approach procedures.

The airspace criteria for approach design changes with aircraft category only when considering circling approach airspace. For category "D" aircraft, this criteria provides you with 2.3 NM of airspace to perform (in the worst case) a 180° base turn maneuver. A category "E" aircraft's airspace provides 4.5 NM of obstacle clearance. For a straight-in approach, the only criteria that might change with aircraft category is the visibility required for the approach. This is because the same airspace is used in obstacle determination for all aircraft categories when designing straight-in approaches. Therefore, the MDA will be based on the same obstacle, providing all aircraft the same MDA.

When a missed approach procedure is designed, the approach designer must make airspace adjustments for turning missed approaches for the var-

ious aircraft categories that may fly the maneuver. The airspace increases as the aircraft's category increases, just as it does for a circling approach. But the distance criteria used for missed approach airspace is different from the distance criteria used for circling approaches. For a category "D" aircraft, the approach designer will use a turn radius of 1.75 NM for the aircraft's flight path (this approximates a TAS of 240 knots). The designer then will provide 1.75 NM obstacle clearance on both sides of this flight path. For category "E" aircraft, the flight path radius is 2.5 NM with 2.5 NM obstacle clearance. As you can see, the approach designer plans for you to accelerate your aircraft during the missed approach. As long as you don't exceed 240 KIAS you should not depart the obstacle clearance airspace for a category "D" aircraft (about 300 KIAS for category "E" aircraft).

Q: When can I descend out of my MDA while flying a circling approach?

A: Obviously, the answer to this question must involve the words "when in a position to make a normal landing." Part of the confusion in deriving the answer to this question involves what you must see (airport environment) to perform the circling maneuver versus what is needed to land (runway environment). In order to dispel some of this confusion, we must understand these two terms.

Looking at AFM 51-37 we find that airport environment is considered to be the runway, its lights and markings, taxiways, hangars and other buildings associated with the airport. On the other hand, runway environment is the runway threshold or approved lighting aids or other markings identifiable with the runway. When performing the circling approach you do not need to keep the runway environment in sight as long as you have the airport envi-

ronment in sight. You will have obstacle clearance providing you maintain at or above the circling MDA and remain within the obstacle clearance area based upon your aircraft category. Now, when may you descend out of the circling MDA? Again, we need to see what AFM 51-37 directs. It says, "do not descend below the circling MDA until in a position to place the aircraft on a normal glidepath to the landing runway." How can you place the aircraft on a normal glidepath without having the runway environment in sight? You can't!

What's the answer to our original question? Depart the circling MDA when you are in a position to make a safe landing (VDP) and you have the runway environment (NOT JUST the airport environment) in sight.

Q: I am being radar vectored and I am turned to my dogleg to final with the following transmission after requesting a localizer approach, "... turn right 270°, maintain 2200 feet until established on the localizer, cleared ILS RWY 31 approach" (see Fig 1). When may I descend out of 2200 feet if I intercept the localizer at 13 DME?

A: To find the answer to this question, we must look in the manual that all instrument pilots should learn to love, AFM 51-37. Paragraph 6-15 talks about pilot responsibilities. Some of these responsibilities are not just to prevent confusion between you and the controller, but to keep you and your aircraft safely flying.

"Once you receive approach clearance, maintain the least assigned altitude and heading until established on a segment of a published routing or instrument approach procedure (IAP)." That's clear enough. I'll stay at 2200 feet until I am on a segment of the approach. You may think that since I am on a segment of the approach. That's not true since the approach doesn't start until 11 DME. If you had

requested clearance for the HI-ILS 1 RWY 31 approach (Fig 2) and received clearance for it, then you would be on a segment of the approach.

But AFM 51-37 has more to say concerning this situation. "From that point, comply with all course and altitude restrictions as depicted on the approach procedure except that you must not climb above the last assigned altitude to comply with published altitude restrictions unless so instructed by the controlling agency." This sentence is telling us that we are to follow the published approach procedures (in-

cluding altitude restrictions) from that point on. Looking at the HI-ILS 1 RWY 31 approach (Fig 2) it is obvious that at 13 DME I must be at or above 3000 feet if I want to ensure that I have obstacle clearance. Looking at the low IAP, it isn't so obvious except that the at or above 3000 feet published for the holding pattern should tell you something about possible obstacles. But why does the controller have you at 2200 feet if obstacles were the problem? You don't know where the obstacle is, but the controller does. He has annotated on his radar what is known as mini-

mum vector altitudes (MVA). This enables him to bring you in at a lower altitude to make the approach easier for you.

To answer this question again, you aren't guaranteed obstacle clearance below 2200 feet until you are past the fix requiring the 3000 foot restriction. Therefore don't descend until you are past this restriction. On this approach, once you reach 11 DME you are cleared to 1500 feet.

Keep the questions coming in, we are always willing to discuss instrument problems. Until next month . . .

FIGURE 1

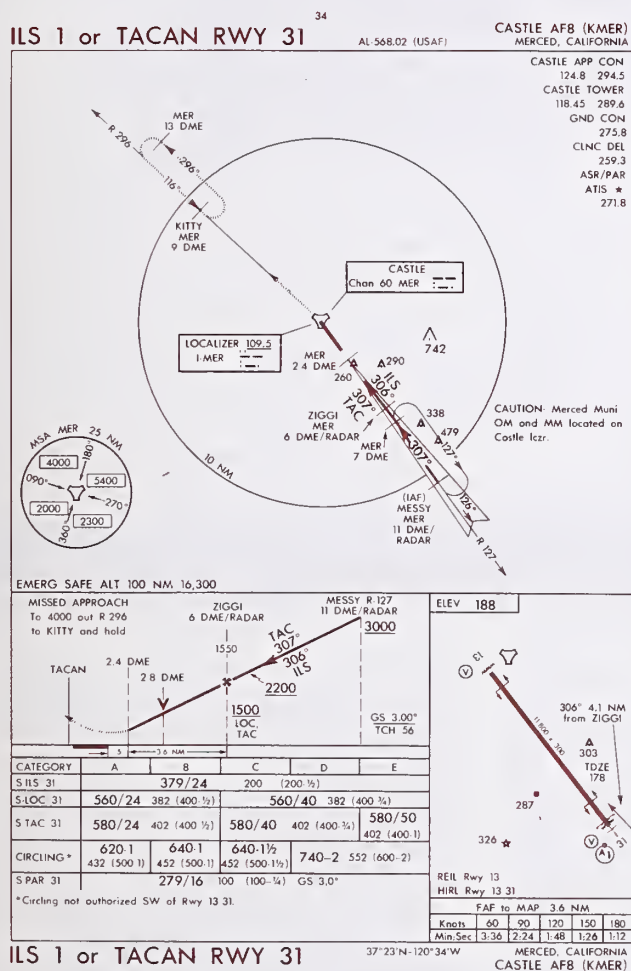
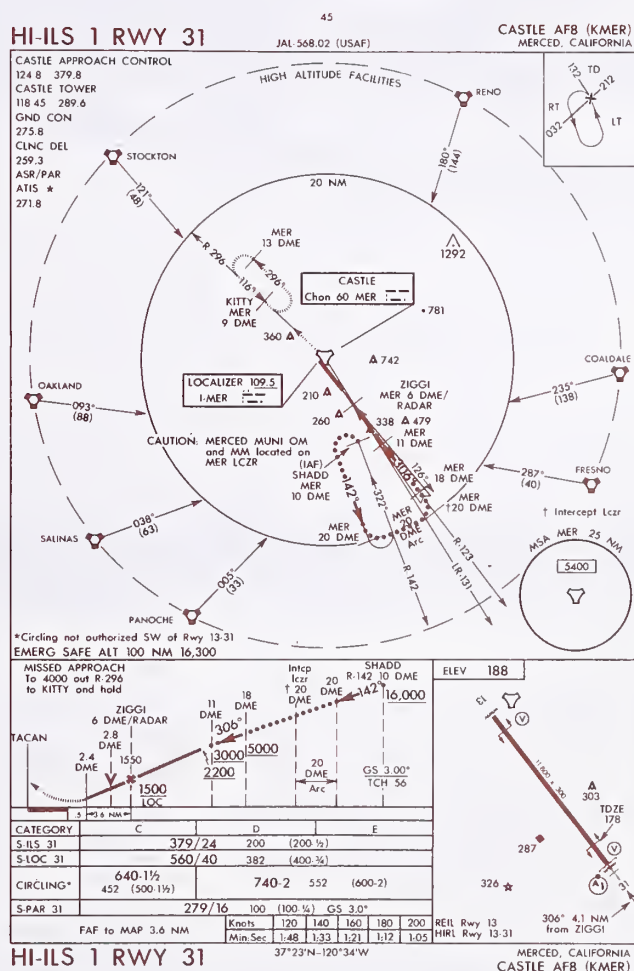


FIGURE 2



TA Myths

Maj Steve Smaby
CFIC, Castle AFB



Throughout the years, many myths about terrain avoidance (TA) operations have developed. Some have been caused because we operators have never really understood the technical operation of the equipment. Some have been perpetuated because the techniques we have used have not kept up with equipment and procedural changes. Finally, even the tech orders have caused some confusion. In this article, I do not intend to take on all the myths about TA operations, but rather deal with some of the more important ones about the compensations.

As far as CFIC is concerned, actual TA flying begins with the FRL compensation. That's why it's important to dispel some of the myths about it, the first being: "The best place to compensate the FRL angle set by the navigator is in a fairly flat area." This could be true depending on the circumstances and what is meant by "best." If "best" means the safest place to begin compensating the TA set, you are perfectly correct. You are not very likely to run into a mountain in a flat area. If you mean it will give you the best information with which to fly TA, you

are correct only in certain circumstances, such as flying TA in a fairly flat area. In mountainous terrain you may have an unsuspected error if you rely on the information gained from a flat area compensation. To explain, I will be referring to figures 1 and 2. In these figures, I have illustrated a TA set which still has a positive tilt after the compensation. This is a situation common to the majority of TA sets. Notice that the aircraft in figure 1 is maneuvering based on the terrain features acquired at the limit of the range gate selected (3 NM). Also notice in moun-

tainous terrain (fig 2) that the airplane is maneuvering on terrain features just before they disappear at the minimum range. Now if you compensated the TA set over a flat area which is compensated for terrain at 3 NM, and they transitioned to a mountainous area where you would be correcting for terrain at the minimum range, you would have an error equivalent to "y" at the minimum range (fig 1). This is precisely why the Dash-11 states: "... adjustment to the FRL angle/clearance plane may be required if the terrain overflown changes from mountainous to flat and rolling or flat and rolling to mountainous." So, as long as we maintain a safe margin above the ground, the TA compensation will be more accurate for mountainous terrain if we accomplish it in a mountainous area and more accurate for flat and rolling terrain when accomplished in a flat area. If you were careful enough to notice that in the previous quotation the clearance plane was also adjusted, then you know this is also true about FVR.

Another myth that exists because of the way the Dash-11 used to read is: "If the FRL mode is inoperative or out of limits, I cannot use the FVR mode." If you have carefully read the recent change to the TA Operational Check, you will see this is no longer true. In fact, the FRL mode was never affected or compared to the FVR mode. They use two different sources for the angular computation of the terrain. The confusion revolved around the terminology used in the old checklist. It used to be called the FRL/FVR comparison. However, we did not really "compare" the two different modes with the procedures we used. What we did do was to compare the planned clearance plane set in the clearance plane gauge to the commanded absolute altitude indicated on the radar altimeter. That is why the new checklist (step number 12) calls it the FVR compensation. We are in essence compensating the FVR mode by adjusting the clearance plane to give us the desired crossing altitude. If the change exceeds 250 feet we will not use FVR and return to FRL.

The final myth I would like to dispel is: "FVR mode is inaccurate and unreliable particularly during accelerations and high airspeeds." During a conference on terrain avoidance held in 1983, it was noted that the angle of

FIGURE 1

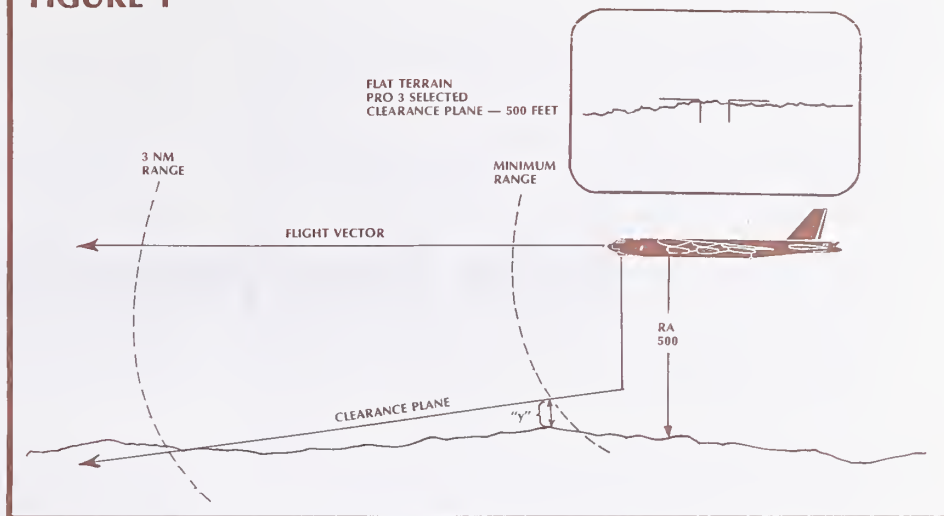
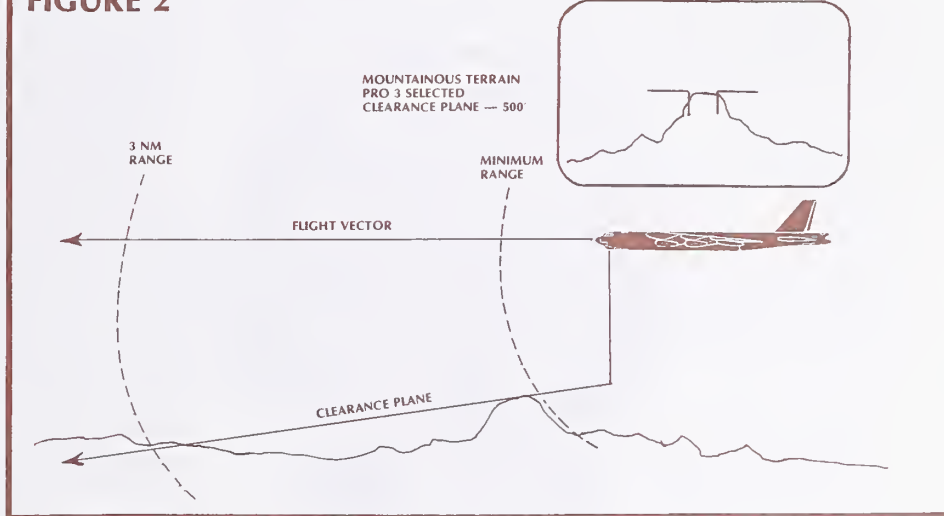


FIGURE 2



attack guide vanes for the FVR mode of the TA set had not been recalibrated for many of the modifications to the B-52; i.e., Phase VI modification of the ECM equipment, etc. Out of that conference came the rumor that FVR was unreliable and should be used only to complete the checklist. Yes, the guide vanes have not been recalibrated; however, the error is minor and we can eliminate it by proper compensation. The advantage of this mode is that it will provide more accurate information since it is continually updating the TA system for airspeed and gross weight changes. Ah! What about the inaccuracies during acceleration and high speeds? Yes, there is an acceleration error, but again it is minor and it should go away when the acceleration is complete. Well, what about the errors at high speeds? There is an angle

of attack error at high airspeeds; however, the technicians estimate that it normally does not exceed 50 feet. Now that all is said and done and you compare the possible errors in FVR with the numerous errors that can be introduced in FRL, I'm sure you will agree that FVR is more reliable as long as it is correctly compensated and does not exceed any of the equipment limitations.

Have you ever been under the influence of any of these myths? If you have, you are probably normal. If not, you are probably an electrical engineer. There are many more myths about TA out there, which we at CFIC are trying to dispel. Your job in the field is to study the system and if there is something you don't understand, or believe, call the experts. Your life could depend on it.

For Instructors Only

Lt Col Charlie Austin
HQ SAC/DOTF

Let's take out pencil and paper and take a brain teaser:

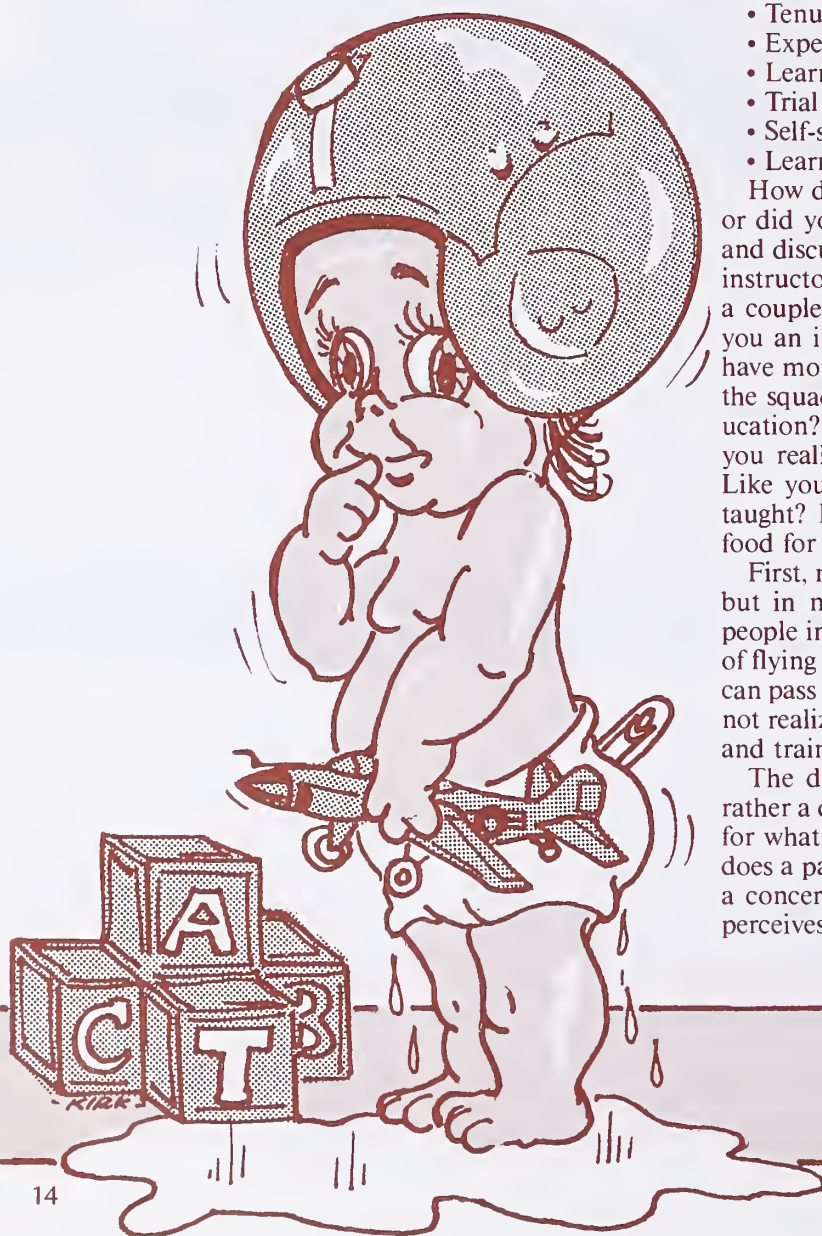
True or false?

- Practice does not make perfect.
- Tenure does not make a good instructor.
- Experience is a poor teacher.
- Learning by mistakes is a waste of time.
- Trial and error learning is inefficient.
- Self-study doesn't work.
- Learning, not training, is more efficient.

How did you do? Did you answer all true or all false or did you have some maybe's? Let's correct to 100% and discuss at the next instructor meeting. Speaking of instructor meetings, at your next meeting, let me suggest a couple of other discussion questions, like: Why are you an instructor? Are you an instructor because you have more flying time than the other crew members in the squadron . . . or you have a masters' degree in education? You are one . . . but how much training have you really had as an instructor? How do you teach? Like you were taught or like you wish you had been taught? Let me stimulate your discussion with some food for thought.

First, most of us would agree that we are not teachers, but in many instances, simply the most experienced people in the squadron, i.e., have the required number of flying hours, have confidence in our flying skills, and can pass an inflight instructor evaluation. What we may not realize is that there is a difference between learning and training.

The difference is not an exercise in semantics but rather a distinction in perception. Training is a concern for what a student does (what his behavior is, how he does a particular thing). On the other hand, learning is a concern for what the student understands (how he perceives the subject matter within his environment).



Both training and learning have a vital place in our unit training programs.

Training is useful if we need to train a person to respond to a stimulus. We often teach bold print emergency procedures to pilots by requiring them to respond to stimuli such as a red fire-warning light. However, this stimulus-response type of training is quickly forgotten by the students unless we continually train and retrain them to respond to the stimuli. By retraining, we reinforce the proper response. This proper response can be reinforced either by presenting a positive reinforcer or by removing a negative reinforcer. This is the old rewards-punishments philosophy.

But there are some "old head" instructors around, like me, who believe this stimulus-response-reinforcement/reward-punishment type of training is not effective when we are trying to teach people **judgment**. Judgment requires an understanding in which fundamentals are so deeply rooted they are never forgotten. This depth of understanding is what I call learning.

For instance, as an instructor, you cannot train your students to respond to every emergency situation that they will be confronted with in the aircraft. However, you can help them gain an understanding of the total environment where these emergency situations occur. From this knowledge of the general environment, they can draw specific facts to solve specific problems that you, as an instructor, might never conceive of as occurring. Therefore, the students acquire a basis for their own judgment.

The instructor plays a most important role in the students' learning process, and must understand exactly what that role entails — to provide a learning environment for the students, to determine what motivates students to learn and then to provide them the motivation to internalize the lessons.

The instructor must also grasp three basic premises about learning. First, we do not really know how people learn. We have clues to motivation, ability to memorize, skills in retention of "learned" information; but in fact, we do not know how people learn. Second, while we do not know **how** people learn, we do know that individuals learn in differing ways. Therefore, we cannot expect each student to learn through the application of just one method of instruction. Finally, it is the instructor's responsibility to select the varied instructional techniques best suited to support the learning of each individual student.

What are some of the best known techniques? They include seven basic modes. First, some students may need individual textbook study in order to gain a func-

tional knowledge of the subject. Some people can just read a book and absorb everything required to understand — I wish I could learn that way.

Second, some students may learn best from schematic drawings, charts and appropriate statistical information. They can gain an understanding by seeing total structure in brief, nontextual form.

Third, some students may not be good readers or visual-type learners but can gain understanding through hands-on experiences. These students learn best by physically handling the switches and the subject matter. This mode is vitally needed for students who do not function well with abstract textbook approaches or schematic presentations.

Fourth, the failure or error experience technique (trial and error) is needed to allow students who learn best in this manner to discover and learn through experimentation and learning by mistakes. This is a variation of the hands-on technique and is carefully designed to provide for mistakes. This technique allows students to find out what will happen through dramatic demonstration of error.

Fifth, some students need a study of "small segments" of the total field of learning. This is a building-block approach in which we allow them to construct each of these small-segment learnings into a large learning field. This mode provides students with growing understanding as each part is learned. It also allows them to treat or study small fields as their personal mode of learning because the larger field of study may be threatening to them.

Sixth, oral study in small groups or pairs of learners may be appropriate to other students. For these students, textual approaches almost ensure failure, even though they may have the potential to learn. I have seen numerous students walk out of a lecture totally confused about a subject; but after a discussion in a small study group they were able to gain total understanding of the subject.

Finally, any combination of the foregoing learning methods may be needed by the students. Many function well when the learning methods are varied; in fact, some students do not realize that they learn better through other than a single instructional process. However, it is essential that the instructor realize it and take it into consideration when preparing the lesson plan.

How do you learn best? How do your students learn best? The next instructor meeting you attend, spend a little time discussing these points — maybe you'll find some useful new techniques to improve your value as a teacher.





HYPOXIA



THE LACK OF OXYGEN IS A REAL GAS

Many people are disturbed about current educational trends. They loudly cry, "Back to the basics!" As a flight surgeon who reviews all of SAC's physiological incidents and mishaps, I've come to the same conclusion regarding flying safety.

There was a time when I thought crew members had heard so many briefings on hypoxia, rapid decompression, nutrition, visual illusion, etc., that they were bored to tears. I thought they needed a new approach. Consequently, I briefed crew members on coronary artery disease, the Holmes-Rahe stress scale, biofeedback, and aerobic conditioning. Not that those aren't worthwhile or interesting topics; however, as I reviewed the command's incidents and mishaps over the last year, I became impressed that the age-old enemies of hypoxia, bends, unauthorized medication, self-imposed stress, and visual illusions are the most commonly noted Life Sciences findings. I'm not saying that every Class A mishap was caused by these conditions, but these culprits were repeatedly noted or suspected.

Your SAC flight surgeons have made a commitment to get back to the basics of flying safety. I've asked them to make sure they review the basic core of flying safety topics that every flyer should know. There is room for debate on what that basic list should include, but as a minimum, I believe crew members should be knowledgeable on these topics:

1. Hypoxia
2. The bends
3. Rapid decompression
4. Fatigue
5. Nutrition

6. Visual illusions

7. Self-imposed stress

Please ask your local flight surgeons to expound and expand on any of these topics at flying safety briefings.

And now, students, class will begin. The subject for today is hypoxia. Hypoxia is a condition that exists when the tissues (especially your "noodle") have insufficient oxygen. Hypoxia is insidious, cunning and bears close watching and drastic correction (sort of like a new flight surgeon). Pain or discomfort rarely gives a clue of hypoxia. Also, individual tolerance to hypoxia may vary from day to day.

The earliest effect of hypoxia is likely to be on your thinking ability, judgment and memory. Decrements in these areas can make you fixate on a task that may not be the most critical at the moment. You may also remember that hypoxia decreases your night vision. Personally, I'd just as soon not fly with you on a night air refueling or in instrument flight rules conditions if you're affected with any of these symptoms (no offense).

You may remember the term **time of useful consciousness (TUC)**. A more appropriate term is **effective performance time (EPT)**. EPT is the time a flyer has, while in a hypoxic environment, to take meaningful corrective action. Let's take a look at a few EPTs:

ALTITUDE (IN FEET)	EPT
18,000	20-30 MIN
22,000	10 MIN
25,000	3-5 MIN
28,000	2.5-3 MIN
30,000	1-2 MIN
35,000	0.5-1 MIN
40,000	15-20 SEC
43,000	9-12 SEC
50,000	9-12 SEC

There is individual variation in EPT

based on physical fitness, smoking habits, "bottle to throttle" time, medications and fatigue. Also, exercise while in a hypoxic environment, such as after a rapid decompression (RD) to greater than 10,000 feet, only decreases your EPT. While on the subject of hypoxia and rapid decompression, do not think you can relax merely because you've gone on 100 percent oxygen after an RD at greater than 10,000 feet. Remember, if the cabin altitude is at 18,000 feet or higher, "You're in Bends Country."

Is hypoxia a real problem in SAC? **Yes!** The incidence of hypoxic episodes is up. With our older aircraft we should not be surprised. Our physiological refresher training should take on a higher priority with all of us. We need to be able to recognize our first symptom of hypoxia, and be able to recognize objective signs of hypoxia in our crewmates. Some of the objective signs of hypoxia are:

1. Increased rate and depth of respiration
2. Blue lips and fingernails
3. Confusion
4. Poor judgment (doing "dumb" things, if you will)
5. Poor coordination
6. Slouching down in the seat
7. Inappropriate behavioral changes, such as inappropriate laughter, anger, crying, etc.

Two other points and we'll dismiss class for today. Do you remember the **PRICE** check and what it is designed to do? Have you recently taken a look at the checklist items pertaining to hypoxia? If the answer to either of these questions is "No," then why not invest 10 minutes in a worthwhile endeavor?

Class dismissed.



It's Water Injection Season Again for the B-52G

Capt Glenn Palmer
HQ SAC/LGME, Offutt AFB

How does throwing water into an engine increase its thrust? How is water injection on the B-52 controlled? What can go wrong? This article will attempt to answer these questions by describing how the water augmentation system on the B-52G works and will review some of the operational practices that can contribute to a successful water injection season.

How Things Work — Hot and Cold

The Boeing B-52G is equipped with Pratt-Whitney J57-43WB engines. Gas turbine engines like the J57 are sensitive to compressor inlet temperature resulting in an appreciable loss in thrust on hot days. To regain this thrust for takeoff, water is injected into the engine. The air entering the engine is cooled as the water vaporizes. Cooling the air reduces the compressor inlet temperature, increasing air density and mass airflow. More and cooler air to the burners permits more fuel to be burned without exceeding engine temperature limits. The result is an increase in thrust.

However, water injection is acceptable only at high engine speeds. As you know, the lower the throttle setting, the less fuel is burned in the engine and the lower its temperature. The internal temperature will drop until somewhere around 70-80 percent N2 speed, where water injection could cool the fuel below fuel combustion temperature, causing an engine flameout or flooding. There are two features in the system design to prevent flooding.

Designing Out Flooding

The first feature is a cam operated microswitch, included as an internal part of the engine fuel control, which permits water injection only when the engine is at high speed. The microswitch for each engine is a series link in the electrical circuit that powers the motor operated water shutoff valve to the "open" position, thus allowing water to flow to the engines. The microswitch is closed when the throttle is advanced above a calibrated position. If the switch is opened, e.g., when a throttle is retarded, the circuit is broken and the shutoff valve is closed. Since there is only one valve per pod, either throttle can stop the water to both engines.

A second feature to prevent engine flooding is referred to as the "inhibit relay." This electrical relay is in the same electrical circuit as the microswitches mentioned above. This relay ensures that a certain sequence is performed before water is supplied to a pod:

- (1) Water switch in the "off" position.
- (2) Microswitches closed, i.e., throttles advanced.
- (3) Water switch to the "on" position.

The logic behind this relay is that under certain circumstances a pilot may have to retard the throttles during a water augmented takeoff. Without the relay, engines could be flooded when water injection resumed following a rapid throttle advance because the engines take some time to get back up to speed.

These features are changes to the original system that were added in recent years to prevent flooding. Prior to system modification under time compliance technical order (TCTO) 785, advancing throttles with the master switch in the "on" position would re-initiate



water. While TCTO 785 modifications should eliminate the possibility of flooding an engine, they also increase the probability of not getting water when you want it.

What Causes Water Dropout? How Things Fail

Since the flow of water to a pod can be interrupted by a microswitch on the B-52G, we should briefly take a look at some of the factors and the people who could impact its setting.

First, the microswitch within the fuel control must be set properly at the overhaul depot using a precision protractor. To use their technical jargon the "power lever angle" (PLA) is set between 59 and 65 degrees for actuation and the deactivation at 3 degrees less than the point for activation. This PLA can be checked by propulsion technicians with recently furnished field protractors.

Secondly, during an engine change, the throttle must be properly rigged. A system of cables and pulleys connects the switch on the engine to the throttles in the cockpit. If the power lever angles on all fuel controls are all set at the designated microswitch actuation point, there should be very little stagger among the individual throttles on the aisle stand. If one is found advanced significantly ahead of the others, then during the takeoff roll, it might be easy to pull it back even with the others. This would cause an inadvertent command to shut off water to that **pod** by opening the microswitch on that **engine**; (remember, either engine switch controls the one pod valve).

The third factor affecting switch actuation is engine trim. The term "trim" refers to the adjustment of the fuel flow to specified engine pressure ratio (EPR) at particular detent positions of the power lever on the fuel control. If an engine is overtrimmed, it has excess fuel flow. The pilot, while setting takeoff EPR, will find it necessary to retard the throttle of the overtrimmed engine more than that of a properly trimmed engine. This causes the throttle, power lever and microswitch to be closer than normal to the cutoff position.

A final factor affecting microswitch opening is EPR setting. EPR readings increase somewhat with aircraft speed. If the EPR is set from a rolling takeoff, the throttles will be further retarded than they would have been had they been set from a standing position. Further, as

the aircraft accelerates and the pilot attempts to maintain the original EPR, he will find it necessary to slightly reduce throttle setting and thus may inadvertently pull it back beyond the point that cuts out the microswitch.

These phenomena are not new, but were largely unnoticed prior to TCTO 785 because the pilot only had to push the throttle forward to reestablish the flow of water. No squawk was written up. With the changes of TCTO 785, the water did not return once lost and the problems were elevated to an incident.

Can Maintenance Help?

Preparing for the Coming Hot Days

Whipping an aircraft's water system back into shape after a long cold winter is not easy. Since water freezes at 32 degrees F, and the B-52 routinely flies with an outside air temperature of minus 40 degrees and lower, freezing of excess water accumulated in water drains is a problem. There are drains at every low point in the system; some spring loaded, others electric-motor driven. All of them stick from time to time, and in general, little attention is paid to a drop of water here and there. When water puddles around these drain valves, it freezes and causes cracks in the housing. Pipes can also be split. All this causes leaks in the system that may go unnoticed by both crew and maintenance.

Inactivity leads to other problems. A system that does not function for some time can grow sticky, or actually break under high engine vibration. That's why there are so many inspection requirements after a B-52G's water system has remained idle several months. Besides filling the aircraft with water and checking for leaks, the cowlings are removed and the plumbing, rigging, trim and general operation of the system are checked under actual flow conditions to each pod.

Another anomaly of interest to the crews should be noted. The fuel control has a water pressure sensing line to initiate the increase in fuel flow during water injection. This line has a small spring loaded drain valve to dump the water after sensing runoff. If this drain valve sticks open, the fuel control may not increase the fuel flow. Water is flowing to the pod and the indication of the companion engine in the pod may appear normal. But because of the low pressure to the one engine fuel control and no subsequent increase in fuel flow, the

EPRs will appear low. This could be interpreted as a water failure when in fact there is no lack of water. Nevertheless, the solution is repair of the water system, i.e., replacement of the defective drain valve.

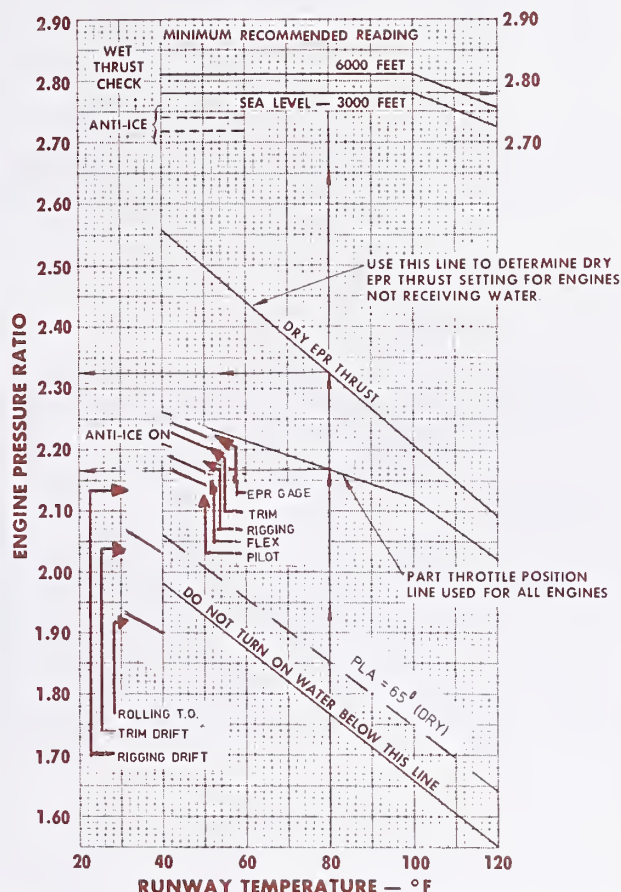
Pushing the Envelope

The concept of system operational limits is a common one. To avoid the possibility of exceeding a limit, a safety margin has been established. The margin is necessary to compensate for various tolerances, normal constructional dimensions, performance drift or other factors. The water injection system and the fuel control switches are also subjected to a safety margin. Instructions for setting dry static engine pressure ratio are contained in the B-52G Performance Manual (T.O. 1B-52G-1-1, Figure A2-12). The upper line of this figure shows the dry EPR as a function of runway temperature. The lower line shows EPR settings corresponding to the points where the water will drop out for a properly functioning system. An additional dashed line has been added to Figure 1 to highlight the relationship between power lever angle (PLA) and the lowest acceptable EPR. The distance between these lines is the margin of safety that ensures the fuel control microswitches are activated. With all the variables within the job guide tolerances, the margin is adequate. But with a "maintenance on demand" philosophy, it is possible for one or more variables to drift over time such that the margin is exceeded. The tolerance buildup depicted on Figure 1 is a worst case, but shows that sufficient error can exist to prevent the desired water injection even when target EPRs are met. The lines converge at lower temperatures, but diverge at higher temperatures. This means there is a higher margin of safety at a higher temperature. Thus it might be expected that the likelihood of a water failure because a limit was exceeded would be higher in the early spring, late fall or at night when the temperatures are down. Fortunately, this is also when consequences of water injection failure are less severe.

The possibility of exceeding a margin of safety suggests that an easy solution would be to spread the lines further. Unfortunately, raising the upper line may cause an engine to overboost. Lowering the line would result in the engine accepting water at a lower power setting and thus increases the possibility of flooding. Either

FIGURE 1.

TOLERANCES AFFECTING SWITCHES



measure would require the overhaul of over 1400 complex fuel controls — a difficult task requiring years to accomplish.

Several measures are being taken this spring to decrease the likelihood of inadvertent loss of water. Additionally, a new method of controlling water injection is being developed to eliminate the fuel control microswitches and their accompanying failure modes. Meanwhile, a better understanding on the pilot's part of the causes of problems with the water injection system will add an important additional safety margin.

Capt Glenn Palmer is an aircraft systems engineer in HQ SAC's Aircraft Engineering Division. His duties include the management of projects to improve the reliability of aircraft mechanical systems. Commissioned as a distinguished graduate through ROTC at the University of Kentucky in 1981, Capt Palmer holds a B.S. in Mechanical Engineering, and is a graduate of the Air Force Systems Safety Officers Course.



Picture yourself penetrating hostile territory in a manned bomber about to confront a variety of airborne and ground threats. What is your reaction? Is this the point where you wished you understood more about electronic combat (EC) and what your EW trains for on a daily basis? That time is now!

Electronic combat is the most dynamic field that confronts the manned penetrating bomber. Gone are the days when electronics and radars were primitive. Also gone is the concept that the "black-box" will do everything to counter threats. EC has become extremely complex. In fact, EC aircraft modifications are the largest dollar item of all aircraft modifications. Range threat simulators for the Strategic Training Route Complex (STRC) and the backyard Strategic Training Range (STR) sites are another major dollar item. The main

How does EC affect the SAC mission? The Soviets have continuously increased their use of the electromagnetic spectrum by fielding large quantities of new surface-to-air-missile (SAM) systems, anti-aircraft artillery (AAA) systems and radar guided airborne interceptors — while still maintaining their older systems. SAC's only experience against this type of threat occurred in Southeast Asia against only one type of SAM, a few AAA systems and a few fighters, threats against which the B-52 aircrew of that era had adequate ECM capabilities. The Soviets, however, have made enormous advances and clearly believe that EC can provide the winning edge in combat. They have continually developed new, sophisticated and complex weapon systems utilizing the electromagnetic spectrum, and we are constantly introducing modifications to keep bombers

EC — "Buzzword" or Discipline?

Lt Col Al Krebs and Maj Chip Kochel
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concept behind EC training is based on "entire crew involvement" in bomber defensive tactics.

So what is electronic combat? It is a **discipline** everyone on the crew needs to understand. AFR 1-1 defines electronic combat as "a specialized task performed by aerospace forces to control selected parts of the electromagnetic spectrum in support of strategic and tactical operations." Electronic combat involves actions to protect friendly electro-magnetic capabilities and actions to neutralize or destroy the enemy's electromagnetic capabilities. The purpose is to enhance the ability of our warfighting systems to achieve objectives, since the use of the electromagnetic spectrum can have a major impact on the success or failure of military operations.

EC includes electronic warfare (EW), as well as elements of Command, Control and Countermeasures (C³CM) and Suppression of Enemy Air Defenses (SEAD).

EW, which this article will deal with, is military action using electromagnetic energy to determine, exploit, reduce or prevent hostile use of the electromagnetic spectrum and also includes actions designed to retain the friendly use of that spectrum.

However, it is important to acknowledge that advances in technology, i.e., lasers, high power microwaves and particle beam technology, are bringing strong emphasis to C³CM and SEAD.

abreast of that threat. During the mid-seventies, the ALQ-117, ALR-46 and ALT-28 systems were added to the B-52, followed in the early eighties by the ALQ-122 and ALQ-155. Today, major ongoing modifications to the B-52 include the ALQ-117 PAVE MINT and the ALQ-172. The FB-111 is also scheduled for ECM modernization and the B-1's state of the art ALQ-161 will provide superior ECM capabilities for our newly fielded bomber.

We know the threats and are procuring the ECM equipment to counter them. The critical question is, how do we prepare our aircrews to confront and degrade these threats with the equipment provided? Training realism is the answer. Historically, aircrew EC ground training has comprised academics, simulator training, crew study on alert, intelligence briefings and tactics discussions. Airborne training consisted of 8-10 minutes conducting an ECM run against older generation simulated threats with severe environmental constraints (altitude restrictions, noise abatement and frequency clearance restrictions), which also limited tactics employed by the crew. In fact, SAC's sole range SAM training simulator, a Quick Reaction Capability (QRC) product of our Southeast Asia involvement, continues to be our primary training and evaluation tool.

Aircraft simulators are of course a very important element of the training program and the B-52 ALQ-T4 presents a representative scenario of threats for training. However, its application is limited to one crew member.

Now, the advent of the B-52 WST, the FB-111 OFT, and the future B-1 WST allows total crew integrated training. These simulators support every aspect of a mission, to include weapon system delivery, electronic combat and bomber defense. Unfortunately, while B-52 WSTs will soon be fully deployed, we are still experiencing problems associated with integrated crew training, especially at the defensive station. Solving these problems, and updating the threat data base and incorporating WST/OFT modifications to keep pace with aircraft modifications, are being urgently worked.

Equal attention is being given to improved inflight training. I mentioned earlier the Strategic Training

aircrew procedures and aircraft system operations. MINI-MUTES, a variant of MUTES, will be able to simulate 3 to 5 signals remotely from a parent site. Some fifty of these will be deployed at permanent, MDL and satellite sites. Additional equipment, such as the ground jammer, will serve to degrade offensive radar systems and enable crews to work in an ECM environment.

The STRC represents a quantum leap forward in SAC's ability to provide a realistic environment for the penetrating bomber in which crews can train utilizing a broad array of tactics for weapon employment and bomber defense.



Route Complex with its associated Strategic Training Center. A major impetus in the STRC is the modernization and procurement of a variety of threat simulation and analysis equipment. The STRC will ultimately be home to six permanent facilities and six mobile facilities capable of bomb scoring and threat simulation. Further additional satellite site capabilities will enable threat simulators to be deployed remotely up to 50 miles away from permanent and mobile duty locations (MDL), resulting in more up-to-date threat simulation with greatly improved threat density. Instead of one ECM run lasting 8-10 minutes, the crews will be confronted with numerous enroute threats, target associated threats and low level airborne intercept activity.

Several range threat simulators are also being acquired. The fourteen multiple threat emitter systems (MUTES) contain a threat file of 59 signals with simultaneous radiation of five threats. Fourteen threat reaction analysis indication systems (TRAINS) will be collocated with MUTES. TRAINS will help close the training feedback loop. TRAINS provides threat and aircraft ECM parametric analysis to determine proper

The STC will be the final step in giving crews the opportunity to see how well they perform. Its operations will include centralized integration with all STRC threats and an aircrew debriefing system. The STC is one of the command's highest priority programs, providing as it will the opportunity to reconstruct and fully analyze a mission. The system will integrate ground range equipment data, airborne threat data and available on-board aircraft data into a crew debriefing system. TDY crews will fly out of the STC and return to attend a formalized critique. Other crews flying from their main operating bases through the STRC will land at their home station to find hard copy results of their performance already in place. Mission critique will be immediate, strongly reinforcing the value of the training. Initial operating capability of the STRC integration with the STC is May 1989.

Now, more than ever, electronic combat plays a crucial role in mission accomplishment. It depends upon — indeed, demands — total crew interaction. The Strategic Air Command is taking strong steps to ensure both aircraft and crews are capable of performing effectively in the threat environment.



PROFESSIONAL PERFORMERS

Aircraft Maintenance

TSgt John F. Tafe, 416 BMW, Griffiss AFB, is SAC's Maintenance Airman of the Month.

As NCOIC of the structural repair shop, he is responsible for the effective management, supervision and training of the largest shop in the squadron. Sgt Tafe can always be counted on to make sure that all milestone dates on critical Rome Air Development Center (RADC) research projects are met. His precise troubleshooting and accurate

decisions often mean the difference between mission accomplishment and failure. His abilities were demonstrated when a B-52G received a bird strike to the strakelet fairing. Since this fairing was part of a new modification for the air launched cruise missile, a repair in this area had never been accomplished in the field or depot. Sgt Tafe had to determine the extent of damage, coordinate with depot on the repair procedures and develop a plan of action for future repairs and changes to technical data. Because of his repair efforts and knowledge of the structural repair field, depot has asked his section to kit

proof and test new TCTOs before they are sent to other units.

With Sgt Tafe's standards of excellence as a motivating factor, his shop is well known for its expertise and outstanding craftsmanship. As a result of his leadership, his shop was recognized by the MSET Technical Excellence Award for the highest possible quality of structural repair maintenance. Sgt Tafe's strong performance was directly responsible for the fabrication branch earning an "Outstanding" rating during the MSET inspection, a rating not duplicated by any other like unit this year.

Munitions Maintenance

SSgt Thomas R. Hipp, 5 BMW, SMinot AFB, is SAC's Munitions Maintenance Airman of the Month. Sgt Hipp's initiative, self-motivation and ability to accomplish any supervisory task place him at the forefront of his contemporaries in unparalleled skill and knowledge. His leadership ability is reflected throughout the sec-

tion by the professionalism exhibited by those who work with him and the consistently high morale of the load crews that he supervises. Assigned in March 1979, his superlative performance began to stand out at once, pointing him out to all echelons of evaluators and supervisors. His enviable record has earned him numerous awards, including two 5MMS Airman of the Month selections, below the zone promotion to SrA, Professional Performer for the SAC IG and MSET,

and a letter of appreciation for a munitions upload demonstration for the Secretary of the Air Force. Because of Sgt Hipp's devoted contributions to duty and mission goals, superior knowledge and unique ability to handle the human element, he has been assigned as a loading section flightline supervisor. In this capacity, he has proven his ability to supervise any work shift, any amount of people and to complete all maintenance documentation, leaving no loose ends.

Missile Maintenance

SSgt John A. Hill, 381 SMW, McConnell AFB, is SAC's Missile (ICBM) Maintenance Airman of the Month. Sgt Hill distinguished himself as NCOIC of the corrosion control team section. With superior management abilities, he led his section to an error free rating during the latest Headquarters SAC/IG visit. A staff assis-

tance visit by 8 AF/19 AD revealed nothing less than an excellent rating in the facilities inspection and an error free rating overall. Sgt Hill then prepared his technicians by ensuring they were well trained for their upcoming 3901 SMES visit. After they had been evaluated, his men were all rated "highly qualified." With technical expertise consistently superb, Sgt Hill sets high standards for quality maintenance. In the past year, he has insured discrepancy free corrosion

treatment of all eight missiles readied for storage during Titan deactivation. Considered an expert, he was hand-picked to accompany senior staff officers and a contractor representative to evaluate the corrosion condition of a missile. To expedite technician transition from aircraft to missile corrosion treatment, he developed an OJT program in direct link with his sister aircraft corrosion shop. Sgt Hill is a dedicated professional, setting a fast pace for his peers and supervisors alike.

TSgt John F. Tafe



SSgt Thomas R. Hipp



SSgt John A. Hill





Missile Crew



Flying Crew

Missile Crew

Crew E-030, consisting of Capt Glenn M. Taylor and 2Lt Randall J. Cross, 351 SMW, Whiteman AFB, is SAC's Missile Crew of the Month.

Capt Taylor and Lt Cross were dispatched to alert recently at Delta Launch Control Center (LCC) with a test launch control panel which was to be used to perform a post maintenance test to a RIVET MILE sortie. After assuming the alert, a Giant Ball exercise was initiated with the SAC Airborne Command Post. Simultaneously, shock isolators 2 and 3 dropped 5 inches. While performing the LCC floor adjustment procedure and compiling squadron sortie and communication status, the crew also assumed missile radio control station for the

wing. The wing command post experienced communication difficulties and the crew also experienced HF and UHF propagation difficulties. They quickly referenced SAC regulations and utilized an alternate means of communication. The crew installed the launch control panel to begin the post maintenance test to the RIVET MILE sortie, when suddenly the maintenance team called and reported that a piece of equipment had fallen and caused a sight impairing injury to one of the maintenance members. The crew coordinated with WCP, job control, codes division and the base hospital through their contingency checklist while simultaneously directing first aid to the injured maintenance member to stop the bleeding and to prevent shock. The alarm response

team was ordered to dispatch to the site to provide additional security while the airman was escorted to the base hospital. Shortly thereafter, the crew received a call over VHF that the maintenance member was in severe pain and possibly in a state of shock. The crew, after coordinating with base agencies, directed the team to divert to a nearby civilian hospital. This lack of hesitancy by the crew insured that professional medical aid was rendered in a timely and efficient manner, thus preventing a possible loss of sight. Besides processing nine maintenance trips throughout the flight area and processing a heavy amount of emergency actions message traffic, the crew successfully completed the remote communications team exercise with the communication team.

Flying Crew

On 24 September 1985, Maj James J. Couch, a former B-52 IP transitioning to the KC-135 and Maj Charles A. Brown, the IP, planned a reduced thrust wet takeoff. This was the student's first takeoff in the KC-135. Maj Brown was in the right seat performing copilot duties.

On takeoff roll, Maj Brown noticed number four EPR was set slightly above the charted 2.64. He tried to refine the number four EPR with a slight throttle reduction but the EPR continued to rise slightly above takeoff rated thrust of 2.83 (the fuel control unit had failed causing the engine to run away).

Maj Brown directed an abort. As the BOLD PRINT was accomplished, the aircraft began to veer to the left of centerline. Maj Brown applied full right rudder and confirmed with Maj Couch that he was applying right nose wheel steering and right differential braking. The aircraft was now approximately 50 feet displaced from the centerline and heading for the left edge of the runway.

Maj Brown applied full thrust on the number one engine, and the aircraft began paralleling centerline with the left truck 12 feet off the runway. As the aircraft responded to this input, a quick scan of the engine instruments revealed number four EPR at 3.00 and

near 100% RPM with the throttle at idle. Maj Brown retarded the number four throttle to cutoff and the engine shut down. The aircraft immediately started correcting toward the centerline so the IP brought the number one throttle to idle. Maj Couch continued to maneuver the aircraft and brought it to a stop 4000 feet down the runway and 50 feet left of centerline. Throughout the abort they were assisted by Capt Randy L. Buckland, IN; 2Lt William A. Neveu, CP; and TSgt Christopher D. Sadler, IBO.

Majors Brown and Couch's quick decisive actions possibly prevented loss of life and loss of a valuable aircraft.

CROSS ~~SAFETY~~ FEED

A Very Bad Assumption

A member of a security police training exercise team was using an explosives device to simulate a terrorist attack. He lit the fuse, but it did not appear to ignite so he continued holding it for several seconds. The simulator exploded in his hand, putting him out of action for several days.

Always Let Somebody Know

A loaded Minuteman RV/G&C van was returning to the missile support base from a launch facility when the rear torsion bar on the trailer came loose at one end, dragged on the ground and caused sparks. The team immediately stopped the van, the missile potential hazard net was established and the situation was safely resolved. Subsequent fleetwide inspection revealed loose screws on two other RV/G&C vans. The reporting system works!

WEAPONS SAFETY



GROUND SAFETY

We're All in the Same Air Force

Score tied. Only a few ticks left on the clock. Time enough for one more play. Suddenly, a player breaks free and drives for what appears to be an easy layup. Then he's put out of action by a "friendly" opponent who delivers a blindside shot to his kidney. Thanks, Rambo.

Bombs Away

While turning hamburgers with a spatula, a cook dropped one of the patties into hot grease which splattered onto his arm and chest. It only takes one mistake . . .

Want it Quick, Get it Quick

While reloading ammunition in his basement workshop area, a great hunter held the ammo in his hand instead of putting it in a shell holder. An unanticipated explosion caused severe lacerations, fractures and contusions to his fingers and palm.

What Else Can Happen?

A young lady fixed a cup of instant coffee using very hot water. As she sat back down in her chair, the handle of the cup came off and the hot liquid saturated her dress and legs.

That Time of Year

The first snow of the year can bring surprises even to a native with six years experience on icy roads. One member panicked when she rounded a curve and her vehicle started to skid. She hit the brakes, slid off the paved surface and flipped over into a ditch. Forgetting the fundamentals of winter driving cost a fractured right shoulder, collapsed lung and fractured pelvis.

We Forgot About What?

0700: B-52 Preflight — Wooden pallet and engine covers strapped in bomb bay.

1100: Low Level Bomb Run — Bomb doors open.

1600: Postflight — Discover damage where pallet and engine covers departed bomb bay.

1601: Explain to wing commander — "No excuse, Sir."

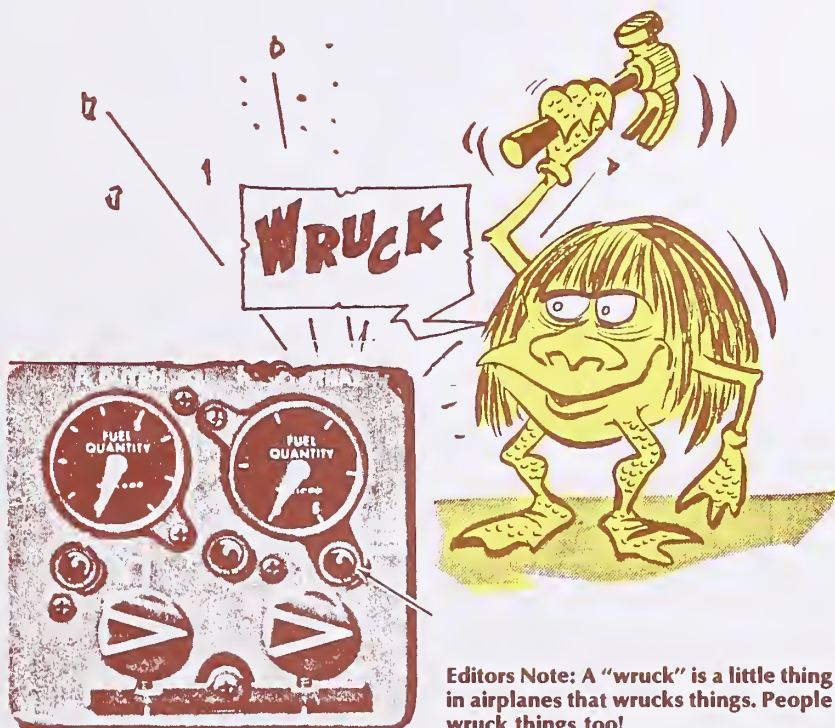
Fuel for Thought

Two recent incidents have shown that the old fuel gauge gremlin is still around. In one case, he convinced the unsuspecting crew they had an out-of-limits aft CG and made them go so far as to move equipment forward since they didn't have fuel available to transfer. Turned out there was only a forward main tank fuel gauge malfunction — it read zero although there was fuel in the tank.

The second case was just the opposite. This time, the gremlin caused the crew to think there *was* fuel in the tank when there wasn't. One indication of the resulting aft CG condition was the nose gear coming off the ground every time the plane hit a bump taxiing in after landing. Luckily, this crew had fuel they could transfer to keep from tipping backward.

Don't take fuel gauges for granted — if things look strange, think about gremlins.

FLYING SAFETY



Editors Note: A "wruck" is a little thing in airplanes that wrucks things. People wruck things too!

Crew Proficiency — A Shared Responsibility

Col Daryl G. Atwood
3901 SMES, Vandenberg AFB

In any missile wing, the operations charter is to ensure a proficient and ready crew force, capable of safe weapon system operation and correct execution of the EWO. This charter can be readily fulfilled through the effective use of three important "training mediums." The first medium is the collective program efforts of the unit's training branches; the second is personal proficiency training which results when the individual crew member fulfills his/her responsibility; the third is standardization evaluation. Yes, that's right — training through evaluations. Any "street smart" missileer understands the timely, crew-force-wide training effectiveness derived from errors committed during evaluation activities.

Each of these training mediums has its place in the operations effectiveness equation because each contributes in a significant but different way. The primary focus of this article is on the latter — training through evaluations. Specifically, let's examine how we may influence the inputs and ultimately affect the outcome — crew effectiveness.

The potential exists that evaluation scenarios and possibly even entire scripts can become mirror images of the problems presented in training scripts. When this happens, the unit pass rate will often increase. Formal failure critiques become less painful because DOVs can readily state that the crew was recently exposed to an identical problem in a training script; and, DOTs can also get "off the hook" because they can just as quickly point out the crew's recent training in exactly the same scenario. This all sounds good as far as formal critiques go — since the crew member cannot effectively use the standard statement — "I was never trained in that." It wraps up the training and evaluation process neatly, leaves virtually no loopholes, and diminishes the "fingerpointing." Everybody happy? Not really.

There is at least one other spinoff from "mirror image" evaluation scripts. That is, they result in the crew force being exposed to a very limited variety of weapon system and EWO problem scenarios, and thereby significantly decrease overall training effectiveness. As the scope of training narrows, one can expect the same to occur to the proficiency of the crew force.

The pitfall lies in the philosophy that before a weapon system or EWO problem can be evaluated, the exact problem must have been presented in the training environment — scenario specific training instead of task

proficiency. That approach reduces the scope of the evaluation programs (which should cover the broad spectrum of task performance and crew requirements) down to those specific scenarios that have been covered in training. The biggest shortfall, however, is that we send a signal to the crew member that if one only remembers exactly what one has seen in training, all bases are covered. Not a good signal to send as it undermines the second training medium — the individual's responsibility to maintain his/her personal proficiency. One additional point — the 3901 SMES and SAC IG do not present mirror image evaluation scenarios.

Training prior to evaluation should expose crew members to the knowledge necessary to accomplish a task or new procedure. Once they have been exposed to that knowledge (not forgetting that crew members have a personal responsibility for maintaining their own proficiency), they should be prepared to handle the variety of scenarios which are inherent in the task.

The optimum process should go like this: Through self-study packages, classroom, and other available media, the crew member is trained on a particular task/subtask. The crew then refines its knowledge and reinforces its proficiency during training MPT sessions which provide challenging problems. Later, when the crew is exposed to variations of that particular problem during alert or evaluation, crew members have the requisite background knowledge, proficiency, and confidence to do the job right.

If this philosophy is a change to present ways of doing business, expect the pass rate to go down — for a short period of time, anyway. The crews or crew members who limit their own proficiency training to exactly what they have been spoon-fed by DOT will more than likely have a tough time reacting to even slight weapon system or EWO scenario variations in evaluation scripts. And, this methodology will reduce the "self imposed" requirement on DOTs to train essentially every possibility and perturbation of each task. It puts the responsibility of overall task proficiency and performance back on the crew members — where it belongs. It broadens the scope of exposure, both through training and evaluation, by increasing task variations and evaluates the proficiency of the crew force — not the training program. As "training mediums" expand, crew proficiency will increase.

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The SAC Safety Screen is an honor roll of SAC's most professional crews. To gain listing on the Screen, crew members must be nominated by their unit commanders and meet high selection criteria of experience in their aircraft or missile system IAW AFR 127-2/SS1.

41 AREFS, Griffiss Crew E-107: IP Capt John Sterret, CP 1Lt John Morrison, IN 1Lt Steve Harvey, BO Sgt Dan DeBellis

41 AREFS, Griffiss Crew R-114: AC Capt Bill Perron, CP 1Lt Tony Palhete, N 1Lt Craig Hanson, BO SrA Bob Boswell

668 BMS, Griffiss Crew S-01: P Capt James R Eckburg, CP 1Lt Edmund L Barnette Jr, RN Capt John A Sargent, N 1Lt Paul J Mejasich, EWO Capt Robert M Homola, G TSgt Gerald G Galinski

509 AREFS, Pease Crew E-112: P Capt Eric M Hansen, CP 1Lt Christopher C Bogdan, N 2Lt Bart T Blackwell, BO TSgt Mark A Kaminski

509 AREFS, Pease Crew E-133: P Capt Sidney O Harriel, CP 2Lt James G Policastro, N 1Lt Evans A Kerrigan, BO TSgt John B Yager

23 BMS, Minot Crew S-02: IP Capt Brooks Tyler, CP Capt Kenneth George, IRN Capt Richard O'Brien, IN Capt Carlos Gonzalez, IEW Capt Alfred Sanchez, IG TSgt Jimmy Williams

23 BMS, Minot Crew R-24: P Capt Kevin Kennedy, CP Capt Jeffrey Olden, RN Capt Neil Fuller, N 1Lt William Jenkins, EW 1Lt Scott Maxwell, G SSgt Thomas Seabolt

23 BMS, Minot Crew E-45: P Capt Al Carter, CP 1Lt Kirk Fansher, RN Capt John Slavoski, N Capt Daniel Clevenger, EW 1Lt Robert Vomela, G TSgt Oleg Nasimok

393 BMS, Pease Crew S-17: P Capt Jim Whitney, N Capt Steve Scolnik

906 AREFS, Minot Crew R-122: AC Capt Annabel S Sparkman, CP 1Lt Ronald E Hansen, NN 1Lt Martha Y Stevenson-Jones, IBO SSgt Steven R Ferguson

325 BMS, Fairchild Crew S-02: P Maj Roy L Widder, CP 1Lt Matthew R Bright, RN Capt Thomas L Sorrell, N 1Lt Paul J McPhee, EW Capt Bryan Zak, AG TSgt Gary W Frederick

325 BMS, Fairchild Crew R-51: P Capt James P Robbins, CP 2Lt Donald P Dunbar, RN Capt David A Golinski, N Capt Jeffrey L Bauer, EW 1Lt James P Lundy, AG SSgt Charles C Shoaff Jr

43 AREFS, Fairchild Crew R-112: P Capt Michael D Swigert, CP Capt Kevin J Brox, N Capt James W Litzinger, B Sgt John M White Jr

43 AREFS, Fairchild Crew R-131: P Capt Roger E A Engelbertson, CP 1Lt Mark A Gregg, N 1Lt Thomas F Yates, B SrA Mark A Schumann

60 BMS, Andersen Crew E-15: AC Capt Peter J Katsufakis, CP 2Lt David E Miller, RN Maj John A Wahlquist, N 1Lt David L Strom, EW 1Lt Jeffery J Warnement, AG TSgt Michael L Schuster

60 BMS, Andersen Crew S-02: AC Maj Donald J Kluk, CP 1Lt Roger N Andersen Jr, RN Capt Wayne B Rowland, N Capt John J Mooney III, EW Capt Robert M Morrison, AG TSgt Robert A Worsham

99 SRS, U-2 Aircraft Commanders, Beale AFB: P Maj Alan E Crawford; P Maj Stephen M Peterson, P Capt Peter S Lemaire

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CROSSING

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